



Explaining FinTech Adoption among SMEs in Pakistan: Extending the Technology Acceptance Model through Financial Inclusion and Financial Literacy

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SMEs play a pivotal role in economic growth, employment generation, and innovation, yet their digital transformation remains constrained by limited access to financial services and inadequate financial capabilities, particularly in developing economies. Although financial inclusion and financial literacy have individually been associated with digital financial innovation, limited evidence exists regarding their combined influence on FinTech adoption by SMEs operating in emerging markets. This study investigates the effects of financial inclusion and financial literacy on FinTech adoption among Pakistani SMEs by extending the Technology Acceptance Model to incorporate these organizational enabling factors. A quantitative, cross-sectional research design was employed, and data were collected from 165 SME owners and managers in Karachi using a structured questionnaire. The proposed research model was evaluated using PLS-SEM. The findings reveal that both financial inclusion and financial literacy positively and significantly influence FinTech adoption. Financial literacy emerged as the strongest predictor ($\beta = 0.658, p < 0.001$), while financial inclusion also demonstrated a significant positive effect ($\beta = 0.301, p = 0.038$). Together, the two constructs explained 43% of the variance in FinTech adoption, indicating moderate explanatory power. The findings extend the Technology Acceptance Model by demonstrating that organizational financial capabilities and access to formal financial services serve as important external antecedents of technology adoption in SMEs.

Keywords: financial inclusion, financial literacy, fintech, technology acceptance model

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1. INTRODUCTION

1.1 Background

SMEs are the key element for modern economies as they create jobs, promote innovation, entrepreneurship, and sustainable economic growth. The role of SMEs is particularly strong since globally SMEs make up 90% of all businesses and provide a considerable share of employment and GDP, thus being essential for inclusive economic development (Beck & Demirgüç-Kunt, 2006). In developing economies, SMEs are of particular significance due to their ability to decrease regional inequalities, promote entrepreneurship, and assist in poverty reduction (Mujahid & Noman, 2020). SMEs are also the essential part of the national economy in Pakistan due to their share in GDP, exports, and job creation (Manzoor et al., 2021). However, despite the economic significance of SMEs in Pakistan, these organizations still face various operational and financial problems hindering their competitiveness and sustainable development.

Constrained access to financial services is one of the major problems faced by SMEs. Conventional financial organizations perceive SMEs as risky borrowers due to the lack of collateral, credit history, information asymmetry, and informal business practices (Beck & Demirgüç-Kunt, 2006). As a result, many SMEs find it difficult to obtain financial means necessary for investments, innovations, business growth, and technological upgrading. Although Pakistan has undertaken different initiatives to improve financial inclusiveness and formal financial service delivery, such as NFIS, the problem of constrained financing continues to limit the potential of many SMEs (Ali et al., 2023). This indicates the need to explore new approaches aimed at providing SMEs with finance and promoting their digitalization.

Recently developed FinTech technologies have revolutionized financial services by enhancing their accessibility, effectiveness, transparency, and cost-effectiveness. Innovations in financial technologies, including mobile banking, digital payments, online financing, cloud financial management tools, and other innovations in financial services have dramatically changed the ways in which businesses can gain and manage financial services (Ashraf et al., 2020). For SMEs, FinTech can be used to overcome traditional problems of financing, decrease costs, increase efficiency and improve decision-making regarding finances, thus enhancing competitiveness of SMEs (Rehman et al., 2020). As a result, adoption of FinTech has become a crucial strategy for SMEs operating in the increasingly digital environment.

However, despite this necessity, the process of FinTech adoption in SMEs in emerging economies is rather uneven. Literature on this topic indicates that mere technological availability is not sufficient to promote adoption of innovations. On the contrary, FinTech adoption requires certain organizational capabilities that include financial resources, managerial skills, technological readiness and institutional support (Tahir et al., 2026). Among these determinants, financial inclusion (FI) and financial literacy (FL) gain considerable attention among scholars. FI enhances access to formal financial organizations, financial products and infrastructure, thus enabling use of innovative financial services (Cevik, 2024).

At the same time, FL provides SME managers with knowledge and skills needed for assessment of financial services, technological innovations, risks and financial decision-making (Mehmood et al., 2026).

1.2 Problem Statement

Even though there has been a lot of growth in the area of digital finance, adoption of FinTech by SMEs in Pakistan has not gained much traction. The previous literature on the topic has mostly emphasized individual customers, mobile banking adopters, or families' financial behaviors but has paid little attention to organizational adoption by SMEs (Shaikh & Karjaluoto, 2015). In addition, most of the literature on financial inclusion and financial literacy has viewed these phenomena separately, ignoring their potential synergy in organizational technology adoption. Consequently, very few insights have been obtained about the joint impact of these two factors on FinTech adoption.

1.3 Research Gap

However, although this relationship has attracted growing academic attention, there are several gaps in the literature that need to be bridged. The first one is the theoretical gap. Previous researches have extensively used the Technology Acceptance Model (TAM) to explain technology adoption; however, not much has been done to expand the TAM to include organizational financial capabilities as external factors affecting FinTech adoption. These organizational financial capabilities include both financial inclusion and financial literacy. Secondly, the contextual gap should be addressed. Majority of the empirical evidence is derived from advanced economies or even focus on individual users, and therefore the relevance of the findings to Pakistani SMEs is questionable given the institution-specific differences, financial market conditions, regulatory environment, and different digital maturity levels. Thirdly, the empirical gap needs to be addressed. Most of the previous studies have mainly focused on examining either financial inclusion or financial literacy separately as compared to considering both factors simultaneously in terms of their effects on FinTech adoption. Fourthly, the methodological gap should be bridged. While the existing literature has mainly emphasized individual technology adoption using consumer-based samples, the organizational-level evidence from the SME owners/managers is still rare. Finally, the practical gap should be filled in. There has been very little evidence about the relative importance of improving financial inclusion and financial literacy in terms of FinTech adoption. This is important for policymakers, financial institutions, and FinTech providers as they need guidance on which factor should be improved more. This issue is particularly important in Pakistan where SMEs play a critical role in economic growth and yet struggle with many financial and technological problems.

1.4 Research Objectives

In response to these gaps, this study seeks to:

- Examine the effect of financial inclusion on FinTech adoption among SMEs in Pakistan.

- Investigate the influence of financial literacy on FinTech adoption among SMEs.
- Extend the Technology Acceptance Model by incorporating financial inclusion and financial literacy as organizational antecedents of technology adoption; and provide empirical evidence to support policymakers, financial institutions, and FinTech providers in designing strategies that accelerate SME digital transformation.

1.5 Research Contributions

The research paper has made valuable contributions to the existing literature in many ways. Theoretical contribution is that it enhances the Technology Acceptance Model by considering the two organizational enablers in terms of financial inclusion and financial literacy for FinTech acceptance. In terms of empirical contribution, the research paper makes contributions by considering organizational level evidence in emerging markets like Pakistan through SMEs which have been under-researched. Research methodology wise, it uses PLS-SEM to test the proposed model conceptually. From a practical point of view, it offers useful insights to stakeholders like policy makers, financial institutions, FinTech companies, and agencies helping SMEs.

1.6 Organization of the Paper

The rest of the essay is structured in the following way. The second section summarizes the related literature, constructs the theoretical base, and formulates the research hypotheses. The third section discusses the research methodology, which includes research design, sample selection, measurement tools, and data analysis methods. The fourth section reports the empirical results of PLS-SEM analysis. The fifth section discusses the results in light of previous literature and explains their theoretical and practical implications. Lastly, the sixth section concludes the paper, stating its contribution, policy implications, limitations, and future work.

2. LITERATURE REVIEW

2.1 Theoretical Foundation

2.1.1 Technology Acceptance Model (TAM)

The fast evolution of digital technologies has led to the fundamental transformation of the financial processes within an organization, providing great possibilities for improving the efficiency, accessibility of financial services and increasing the competitiveness of the organizations. Although there are many possibilities provided by digital financial technologies, there is a lot of variance among different organizations regarding their ability to adopt them. This issue makes the investigation of the factors that determine the adoption process highly relevant for the information system research and FinTech studies (Firmansyah et al., 2022). The

TAM presented by Davis (1989) is one of the most popular and empirically supported models of technology adoption.

The TAM was originally formulated in an effort to understand whether individuals accept or reject information technology innovations. Based on Theory of Reasoned Action (Fishbein & Ajzen, 1975), TAM theorizes that the decision to adopt new technology is mainly dependent on two kinds of cognitive beliefs, namely, usefulness and ease of use. Usefulness refers to how useful one perceives the technology to be for enhancing his or her performance, while ease of use concerns how easy it is to learn and use the technology. These beliefs are responsible for shaping users' attitudes towards technology, determining their behavioral intention and ultimately their adoption of technology (Davis, 1989). For over three decades now, TAM has found application in multiple fields of technological innovation such as e-commerce, mobile banking and electronic payment systems, cloud computing, artificial intelligence, block chain technology, and more recently, FinTech (Mondego & Gide, 2022).

While TAM was originally created for explaining individual adoption of technology, it has been proven recently that it is relevant for decision-making in organizations, especially SMEs (Nazir & Khan, 2022). Unlike large companies, SMEs usually face restrictions regarding finances, technology and human resources that play an important role in technology adoption. Therefore, technology adoption decisions in SMEs are not only influenced by the perceived features of the technology itself but also by the presence of the external resources and managerial skills necessary for implementation. The extensions of TAM consider the fact that the external factors such as contextual, organizational and environmental factors influence the perception of usefulness and ease of use of the technology (McFarland & Hamilton, 2006).

FI and FL represent two major external antecedents that have an impact on technology acceptance in terms of FA within the context of SMEs. FI leads to enhanced accessibility of firms to FINs, financial infrastructure, and financial products, which leads to reduced barriers associated with the implementation of financial technologies. SMEs having better connections with FINs are more exposed to digital banks, mobile payments, online lending, and other FinTech innovations. Increased awareness about digital financial services and benefits provided by such innovations contribute to increased perceptions about their usefulness for the firm performance (Munir & Wahab, 2024).

Likewise, the impact of FL on technology adoption is seen in managers' greater understanding, analysis skills, and confidence in making decisions about finances. Owners and managers with more FL have an easier time understanding digital financial innovations, assessing risks and benefits, analyzing financial information, and implementing innovations into the organization's operations. Increased financial knowledge leads to lower uncertainty regarding innovations in technology and greater confidence of managers in using digital financial solutions (Qazi et al., 2025). This means that managers with FL find FinTech applications more usable and less difficult, thus making their willingness to adopt them higher. From point

of view of TAM, FL is a determinant of perceived usefulness and perceived ease of use.

Empirical studies in recent years have continued to extend the TAM framework by including contextual factors pertinent to digital finance. The researchers have found that organizational readiness, digital literacy, FL, institutional support, technology infrastructure, and FL play an important role in influencing the acceptance of FA by altering the perception of users about the utility and usability of technology (Marei et al., 2023; Hu et al., 2019). It indicates that the acceptance of technology depends not only on the attributes of technology but also on the institutional and organizational setting in which the adoption decision is made. This extension has enhanced the scope of explanation by TAM, especially in the context of developing economies.

The significance of TAM is particularly apparent in Pakistan's SME sector, where digital financial transformation is still in its early stages (Nazir & Khan, 2024). Although government initiatives, such as the NFIS, have increased access to digital financial services, adoption among SMEs remains inconsistent due to disparities in financial access, technological awareness, managerial competencies, and digital capabilities (Seft et al., 2024). Many SMEs continue to rely on traditional financial practices despite the growing availability of digital financial solutions (Khan et al., 2026). In this context, FI and FL serve as essential enabling conditions that help managers recognize the value of FinTech and reduce the complexity of adopting digital financial technologies. Therefore, TAM offers a suitable theoretical framework for explaining why some SMEs readily adopt FinTech innovations while others remain hesitant, even within similar institutional environments.

This study adopts the TAM as its primary theoretical framework because it provides a comprehensive explanation of how external organizational factors influence technology adoption behavior. Rather than viewing FA solely as a technological decision, the study acknowledges that access to financial services and managerial financial knowledge shape SMEs' perceptions of the value and usability of digital financial technologies. Accordingly, FI and FL are conceptualized as external determinants that promote technology acceptance by enhancing perceptions of usefulness and ease of use, thereby increasing the likelihood of FA among SMEs in Pakistan.

2.2 Hypotheses Development

2.2.1 Financial Inclusion and FinTech Adoption

The concept of FI is an essential aspect of economic development in the global economy due to its ability to help with financial inclusivity, reducing disparities, and ensuring sustainable economic growth. According to the World Bank, financial inclusion is defined as the provision and efficient usage of affordable, accessible, and appropriate financial services to individuals and enterprises. While FI strategies initially concentrated on providing access to traditional banking services, technological advancements have led to the evolution of FI, which now entails the

inclusion of digital financial services in formal finance institutions. Thus, FI no longer revolves around merely providing access to bank accounts; rather, it entails the adoption of digital payments, digital banking, digital credit services, digital savings, and insurance as well as other digital financial services. In such a way, FI becomes a driving force behind digital transformation of SMEs as a result of their limited access to formal financial services.

In the context of SMEs, FI is strategic because it helps address the financing problems that have long hampered companies' capability to adopt technology and innovate. For one, SMEs experience information asymmetries, collateral inadequacies, poor credit histories, and high borrowing costs, all of which make it difficult for them to get formal financing services (Ali et al., 2023). The combination of these challenges leads to limited investment capacity and limits opportunities for the adoption of innovative financing technologies. Through improved FI, however, SMEs can get access to formal FINs and more financing options that suit their needs. SMEs are thus better placed to adopt innovative FinTech services such as the use of digital banking services, electronic payments, online financing options and many others due to FI. Recent research evidence is showing increasingly strong links between FI and FA in developed and developing countries alike. Research shows that organizations with higher levels of FI adopt digital financial technologies because they are exposed to formal financing institutions that create more awareness and accessibility of technology-based finance products (Chowdhry & Iqbal, 2026). FI makes regular contact between the firm and formal financing institutions possible, exposing organizations to innovations in finance that promote switching from conventional financial services to digital finance services. FI promotes organizational digital transformation in terms of adoption of innovative financial services because it enhances familiarity with financial technology innovations.

But empirical research shows that the association between FI and FA is neither automatic nor uniform across countries (Sharma, 2026). The quality of institutions, the development of digital infrastructure, the nature of regulatory framework, and financial market structure are among the major determinants of the success of FI programs. In developed countries, with an existing digital infrastructure and well-developed financial market system, increased FI tends to lead to increased rates of FA due to the favorable institutional environment (Frost, 2020). In most developing countries, lack of technological infrastructure, uncertainties in the regulatory environment, underdevelopment of FINs, and inadequate digital literacy tend to reduce the effectiveness of FI programs. Pakistan's SME industry presents an appropriate setting for evaluating the connection between FI and FA. In spite of the great measures taken by the government in promoting the use of FI through NFIS, branchless banking, digital payments, and mobile banking services, there are many SME businesses that still conduct themselves informally (Khan et al., 2021). This is mainly because of the rigid documentation process, collateral problems, and lack of access to credit facilities. Moreover, geographical differences in terms of technology and finance hinder the use of FinTech products by SMEs (Tahir et al., 2026). These institutional challenges emphasize the importance of improving FI to facilitate financial digitalization of the SME industry.

According to the TAM theory, financially included organizations act as a critical external determinant that affects SMEs' perceived utility and availability of FinTech products (Ashraf et al., 2023). As the access of FINs increases along with digital financial infrastructure, organizations get exposed to new financial technologies and thus increase their belief that adoption of such technologies improve the performance and efficiency of business operations. Moreover, financial inclusion is an important organizational capability that helps organizations to access financial resources necessary for investments in technology. Overall, from all the theoretical frameworks mentioned above, it is clear that financially included SMEs are more ready to adopt digital FinTech technologies. Even as digital finance has emerged as an important area of study for scholars, there remain a number of important gaps in research. The first of these is the fact that a lot of the literature has concentrated primarily on individuals, or mobile banking users or households' FI, while there has not been enough attention paid to SMEs as organizations using FinTech solutions. The second gap is that most of the previous research has been done in advanced countries or quickly developing countries like those in Asia, which limits the extent to which such results can be generalized to emerging markets with institutional deficiencies and financial exclusion.

This is significant in the context that despite SMEs being the backbone of the economy in Pakistan, there have been very few studies on the digital financial transformation process in this segment (Mushtaq et al., 2024). The current study, through investigating the effect of FI on FA amongst SMEs in Pakistan, this add value to the growing body of knowledge related to digital finance and organizational technology adoption in emerging economies. Based on the TAM theory and previous studies indicating that improved access to FINs makes an organization more ready to innovate digitally, the following hypothesis is proposed.

H1: Financial inclusion has a positive and significant effect on FinTech adoption among SMEs in Pakistan.

2.2.2 Financial Literacy and FinTech Adoption

Financial literacy has become a critical determinant of organizational decision-making in the context of an increasingly digital financial environment. As financial markets advance in sophistication and technological integration, entrepreneurs and managers must possess the ability to comprehend financial concepts, evaluate financial products, and make informed decisions to maintain organizational competitiveness. FL extends beyond basic accounting or bookkeeping; it includes the capacity to interpret financial information, assess financing alternatives, manage financial risks, evaluate investment opportunities, and effectively utilize digital financial services (Learn, 2026). In the context of SMEs, FL constitutes a strategic managerial competency that affects both financial performance and organizational readiness to adopt technological innovations that transform financial management practices (Rosyidha & Mardiana, 2026).

SMEs typically operate within the limited financial resources, face uncertain business environments, and experiencing increasing competitive pressures. As a

result, managerial competencies serve as essential organizational assets that influence the ability to identify opportunities, allocate resources efficiently, and respond to technological change. Entrepreneurs with strong FL are better positioned to evaluate the economic benefits of innovative financial technologies, compare alternative financing mechanisms, understand transaction costs, and assess risks associated with digital financial services. This knowledge reduces uncertainty related to technological investments and increases managers' confidence in integrating FinTech solutions into business operations. Conversely, limited FL often leads to poor financial planning, suboptimal investment decisions, and reluctance to adopt innovative technologies due to heightened perceptions of uncertainty and implementation risk (Aftab et al., 2023).

The rapid growth of FinTech has further elevated the significance of FL within organizations. Modern financial technologies, such as digital payment systems, mobile banking applications, cloud-based accounting platforms, peer-to-peer lending, crowd funding, block chain-enabled financial services, and artificial intelligence-driven financial applications, require users to possess both financial and technological knowledge for effective utilization (Tahir et al., 2026). Unlike traditional financial services, digital financial platforms often necessitate that users independently evaluate financial information, navigate digital interfaces, manage cybersecurity risks, and make real-time financial decisions (Essandoh et al., 2025). Therefore, successful FA depends not only on technological infrastructure but also on managers' financial competence and confidence in utilizing technology-enabled financial products.

Recent empirical research increasingly identifies FL as a significant predictor of digital FA (Chowdhry & Iqbal, 2026). Studies from both developed and emerging economies consistently find that financially knowledgeable entrepreneurs are more willing to adopt digital banking, electronic payment systems, online financing platforms, and other FinTech services (Abbas & Khan, 2024). FL improves individuals' understanding of the benefits associated with digital financial innovations, such as enhanced operational efficiency, reduced transaction costs, increased financial transparency, and improved access to financial markets (Waqar et al., 2025). Additionally, financially literate managers are generally more adept at evaluating the strategic value of technological innovation, which increases organizational readiness for digital transformation (Duréndez et al., 2023). Collectively, these findings indicate that FL serves as a key organizational capability that facilitates technology adoption through improved managerial decision-making and a stronger orientation toward innovation.

However, empirical evidence remains inconclusive regarding the magnitude and consistency of the relationship between FL and FA. Some studies report a strong positive association, suggesting that financially competent managers exhibit greater confidence in utilizing digital financial services (Abbas & Khan, 2024). In contrast, other research indicates that FL alone may be insufficient to promote technology adoption in environments with weak institutional support, inadequate digital infrastructure, or limited access to formal financial services (Kandhro et al., 2026). These findings suggest that the effectiveness of FL is contingent upon contextual

factors that either facilitate or constrain the practical application of financial knowledge. As a result, the influence of FL on FA may vary significantly across countries, industries, and institutional settings. These contextual differences are especially pertinent in Pakistan, where SMEs often exhibit low levels of financial capability and inconsistent access to financial education (Akhtar & Liu, 2018). Despite significant growth in digital financial services over the past decade, including mobile banking, branchless banking, digital wallets, and online payment systems, many SME owners remain unfamiliar with the financial products and technological capabilities offered by the formal financial sector (Mustafa & Waheed, 2016). Limited understanding of digital financial instruments, along with concerns about cybersecurity, regulatory compliance, and technological complexity, frequently discourages SMEs from adopting innovative financial technologies (Fatima et al., 2022).

The TAM provides a strong theoretical explanation for this relationship by proposing that external variables influence technology adoption through their effects on perceived usefulness and perceived ease of use (Burton-Jones & Hubona, 2006). FL enhances managers' understanding of digital financial technologies, enabling them to recognize the operational benefits associated with FinTech while simultaneously reducing perceptions of technological complexity. Managers possessing higher financial knowledge are therefore more likely to perceive FinTech solutions as useful, reliable, and manageable, thereby strengthening their intention to adopt these technologies. Similarly, FL is a valuable knowledge-based organizational capability that enhances firms' innovation capacity and competitive advantage. Financially knowledgeable managers represent intangible organizational resources capable of identifying technological opportunities, evaluating investment alternatives, and successfully integrating digital innovations into organizational processes (Mir & Sheikh, 2026).

Despite increasing scholarly attention to FL in digital finance research, several important gaps persist. First, much of the existing literature focuses on individual consumers, students, or household financial behavior, with comparatively less emphasis on SMEs in emerging economies (Stolper & Walter, 2017). Second, many studies examine FL as an outcome of financial education rather than as a strategic antecedent to organizational technology adoption (Qazi et al., 2025). Third, empirical research from Pakistan remains limited, even as the country places greater emphasis on digital FI and SME development (Munir & Wahab, 2026). Additionally, few studies have investigated FL alongside FI within a unified theoretical framework explaining FA (Ashraf et al., 2020). Addressing these gaps is crucial, as the digital transformation of SMEs depends not only on technological availability but also on the financial competencies of organizational decision-makers responsible for adopting innovative financial technologies. Drawing upon the Technology Acceptance Model and growing empirical evidence highlighting the strategic importance of managerial financial competencies in digital transformation, this study proposes that FL positively influences FA among SMEs in Pakistan.

H2: Financial literacy has a positive and significant effect on FinTech adoption among SMEs in Pakistan.

2.3 Research Framework

Figure-1 shows the research framework for the study developed by the research to identify the impact of FI and FL on FA by SMEs in Pakistan. In total there are two independent variables including FI and FL and one dependent variable that is FA in Pakistan by SMEs.

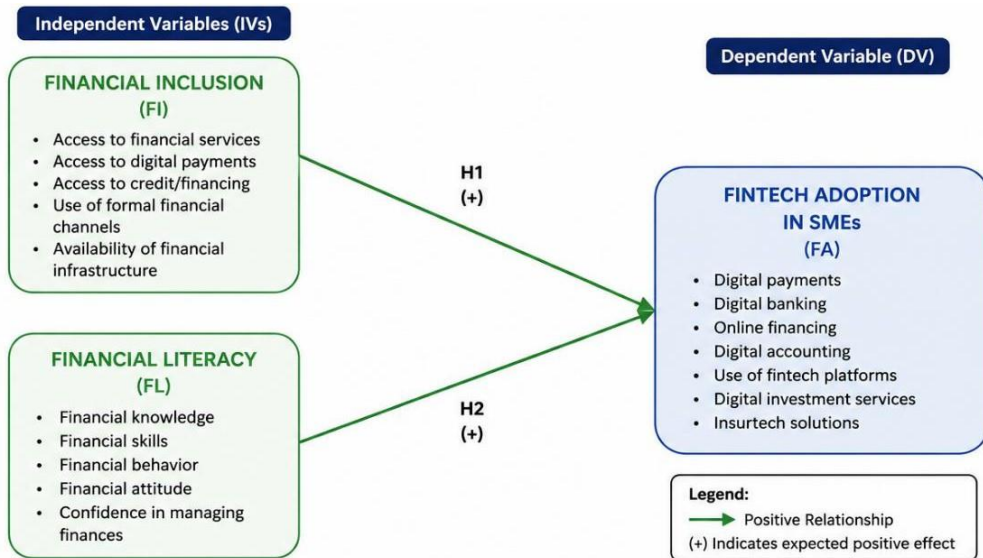


Figure 1: Framework
Source: Authors Construction

3. RESEARCH METHODOLOGY

Quantitative research methodology is used to analyze the effect of FI and FL on FA for SMEs operating in Karachi, Pakistan. The research methodology is based on the Research Onion concept introduced by Saunders et al. (2023), which provides a framework for developing and executing business and management research. Researchers can make the right methodological decisions at each step by making moves from philosophical assumptions to data gathering and analysis in accordance with the Research Onion concept (Saunders et al., 2023). Philosophically, the research belongs to the positivist paradigm. According to positivism, reality is seen as an objective entity that can be measured and is not influenced by researchers, which allows the examination of relationships between variables through empiricism and statistical analysis (Saunders et al., 2023).

In accordance with the positivist philosophy, a deductive approach is used. The deductive research method starts with a theory or hypothesis that has been developed based on the existing literature in previous studies and tests this theory using the collected data. The framework of the study is built on the basis of the TAM theory from which two hypotheses about the effects of FI and FL on FA in SMEs have been generated. Deductive approach fits the purpose of the research perfectly well because it allows testing theory rather than developing one and empirically testing the theoretical assumptions. As far as research strategy is concerned, the study uses a survey strategy, which is one of the most popular research strategies used in management, finance and information systems research.

As per the research opinion of Saunders, the research involves a mono-method quantitative research approach where data would be collected in quantifiable form and analyzed using statistical tools. Mono-method research approach is chosen to be suitable for this research since the focus of the research is on finding the relationship between the constructs pre-defined by the researcher through structured questions having a five-point Likert scale. In terms of time-horizon, the research involves cross-sectional approach where data collected from the respondents in one-time only. The cross-sectional research design is most suitable in order to find out the current practices and intentions of the organizations without making longitudinal observations. The target population includes SMEs that operate within Karachi, Pakistan. Karachi stands as the biggest business and industrial city of Pakistan and hosts a significant number of SMEs in manufacturing, trading, services, retail, logistics, information technology, healthcare, hospitality, and professional services (Iqbal & Ullah, 2017). Karachi has better digital infrastructures and financial systems and therefore an ideal setting for studying the FA process. The unit of analysis is SME owners who are part of the financial decision-making and have enough knowledge about the financial management and digital finance technologies of their organizations.

The primary data is collected through a self-administrated questionnaire which is the main data collecting tool. The questionnaire is constructed based on adaptation of measurement scales used in previous peer-reviewed literature studies to guarantee content validity and construct reliability (Huijg et al., 2014). Measurement items rated on a five-point Likert scale: 1 – Strongly Agree to 5 – Strongly Disagree. According to the conceptual model, FI is measured by about 5 items related to formal financial services access, availability of digital payment systems, availability of credit facilities, usage of banking services, affordability of financial products, availability of digital financial infrastructure, conducting digital transactions, interacting with FINs, accessibility of mobile banking, and overall participation in the formal financial system.

Table 1: Variables and Measurement Tool**Source: Literature Review**

S.No.	Variable	Description	Item
1	Independent Variable	Financial Inclusion	1. Our business has easy access to banking services. 2. Our business maintains an active bank account for business transactions. 3. Financial institutions offer products and services that meet our business needs. 4. Our business can obtain financing from financial institutions when needed. 5. Business loan products offered by financial institutions are suitable for our business. 6. Financial services provided by financial institutions effectively support our business operations.
2		Financial Literacy	1. We regularly analyze our business's financial performance. 2. We understand how to prepare and interpret financial statements. 3. We understand key financial ratios and performance indicators. 4. We can accurately calculate loan interest and repayment obligations. 5. We understand the costs and benefits associated with business borrowing. 6. We understand the importance of maintaining business savings and cash reserves.
3	Dependent Variable	FinTech Adoption	1. Our business regularly uses digital payment platforms for business transactions. 2. Our business uses mobile banking applications to manage financial transactions. 3. Our business frequently uses online financial services. 4. Our business has adopted FinTech services in its financial operations. 5. Our business intends to continue using FinTech services in the future. 6. Our business plans to expand its use of FinTech services.

FL is determined through about 6 items that assess the degree of the respondents' FL, financial budgeting, interest rate knowledge, investment literacy, financial planning, risk assessment, cash flow management, financial statement analysis, knowledge of digital financial tools, and confidence in decision-making in finance.

FA, which serves as a dependent variable, is determined through about 6 items that measure the degree of use of digital payments, mobile banking, money transfers through internet, digital accounting systems, financing through internet, electronic invoicing, cloud financial applications, digital financial records management, FinTech platforms usage for business, and intentions to expand the use of digital financial technologies in the future (Shahbaz et al., 2012).

Purposive sampling, which is a non-probability sampling method, is used to sample the respondents based on some characteristics that would be relevant to the study. The selection of sample size is guided by the latest methodology guidelines for PLS-SEM. Though the widely used 10-times rule has often been used in previous research, modern methodological literature finds it inadequate because the sample size requirement estimated based on it tends to be too low. The Inverse Square Root Method (ISRM) and the Gamma-Exponential Method (GEM) have been recommended as more precise methods for the estimation of minimum sample size in PLS-SEM by recent methodological sources like Kock and Hadaya (2018). The current study uses the G*Power software to identify the minimum sample size require for the generalizability of the findings. Besides, G*Power statistical power analysis has been advocated as a way to ensure appropriate statistical power for hypothesis testing by Hair et al. (2022). Since the SEM under consideration includes two exogenous constructs as predictors of one endogenous construct, and the assumed medium effect size ($f^2 = 0.15$), the significance level ($\alpha = 0.05$), the required statistical power (0.95), and two predictors, G*Power estimates the minimum sample size at about 107 respondents. However, in order to increase the statistical precision and external validity of the results and to cover any possible non-response, the respondents in this study are targeted in Karachi (Kock & Hadaya, 2018).

4. RESULTS

4.1 Demographic Analysis

Table presents below regarding the demographic characteristics of the 165 SME owners and managers surveyed in Karachi. Male respondents constituted the majority of the sample (70.3%), while females represented 29.7%. Most respondents were between 31–40 years (35.2%), followed by 41–50 years (28.5%), indicating that the majority were in their active entrepreneurial years. Regarding education, 43.0% had completed Matriculation/O-Levels, 37.0% had Intermediate/A-Levels, 10.9% had middle-level education, while 9.1% possessed graduate or postgraduate qualifications. In terms of business experience, the largest group (32.7%) had 1–3 years of experience, followed by 4–6 years (27.3%). Finally, 60.0% of the participating firms were small enterprises (10–49 employees), whereas 40.0% were medium-sized enterprises (50–249 employees). Overall, the sample represents a diverse group of SME owners and managers, providing an appropriate basis for examining the determinants of FinTech adoption.

Table 2: Demographic analysis
Source: Authors Estimation

Demographic	Category Variable	Frequency	Percentage (%)
Gender	Male	116	70.3%
	Female	49	29.7%
Total		165	100%
Age	<30	32	19.4%
	31-40	58	35.2%
	41-50	47	28.5%
	51-60	26	15.75%
	>60	2	1.2%
Total		165	100%
Education	Middle	18	10.9%
	Matriculation / O-Levels	71	43%
	Intermediate / A-Levels	61	37%
	Graduate	10	6%
	Postgraduate	5	3.1%
Total		165	100%
Business Experience	<1	30	18.2%
	1 - 3	54	32.7%
	4 - 6	45	27.3%
	7 - 9	30	18.1%
	>10	6	3.63%
Total		165	100%
Firm Size	10-49 (Small)	99	60%
	50-249 (Medium)	66	40%
Total		165	100%

4.2 Measurement Model Assessment

Measurement model (MM) evaluation was carried out before the structural relationship analysis of the latent constructs. Following the guidance by Hair et al. (2022), the following MM assessments were carried out: indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. These assessments affirm the construct representation of the measurement items and the empirical separateness of the constructs. Figure 2 shows the graphical presentation of the MM, outer loadings of each items are reported on the given model.

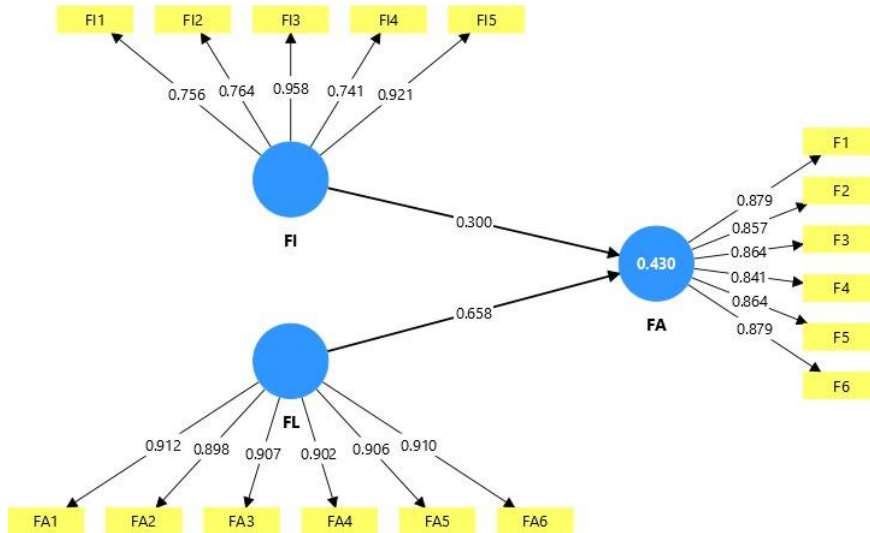


Figure 2: Measurement Model

4.2.1 Indicator Reliability (Outer Loadings)

To measure the reliability of indicators, the outer loadings of every single item of measurement were used. According to Hair et al. (2022), standardized outer loadings of every indicator should be greater than 0.70 to make sure that every indicator reflects latent constructs. All measurement items had acceptable factor loadings, varying from 0.741 to 0.958. It should be pointed out that factor loadings of FI varied from 0.741 to 0.958.

Table 3: Outer Loadings
Source: Authors Estimation

	FA	FI	FL
FA1	0.879		
FA2	0.857		
FA3	0.864		
FA4	0.841		
FA5	0.864		
FA6	0.879		
FL1			0.912
FL2			0.898
FL3			0.907
FL4			0.902
FL5			0.906
FL6			0.910
FI1		0.756	
FI2		0.764	

FI3		0.958	
FI4		0.741	
FI5		0.921	

All measurement items used for measuring FL had loadings that varied from 0.898 to 0.912, signifying that all indicators used for the construct had good loadings. For FA, the loadings for its indicators varied from 0.841 to 0.879, exceeding the minimum criteria. Since the loadings were above 0.70 for all variables, there was no need for the removal of any variable. This signifies good reliability of the indicators.

4.2.2 Internal Consistency Reliability

Internal consistency reliability analysis was done using CR and CBA. As per the guidance of Hair et al. (2022), the two coefficients should have values greater than 0.70, where 0.70 to 0.95 is considered acceptable for the constructs' internal consistency. The results show good reliability for all constructs. FA obtained a CBA of 0.932 and a CR of 0.946, suggesting good internal consistency of the construct. FI scored a CBA of 0.913 and a CR of 0.918, which implies high internal consistency of the construct measurement items. FL attained the best reliability coefficient with a CBA of 0.956 and a CR of 0.965.

Table 4: Construct Reliability and Validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)
FA	0.932	0.935	0.946
FI	0.913	0.966	0.918
FL	0.956	0.960	0.965

4.2.3 Convergent Validity

Convergent validity is concerned with how much common variance is shared among the indicators measuring the same construct. According to Hair et al. (2022), convergent validity is achieved when the value of the AVE is greater than 0.50. The value of the AVE for all the constructs analyzed in this study was far greater than the required threshold value. For instance, the value of the AVE for FA was 0.747. This indicates that 74.7% of the variance of the indicator is explained by the construct. For FI, the value of the AVE was 0.694, which means that 69.4% of the variance was explained by the construct. FL had the greatest level of convergent validity because its value of AVE was 0.821, which meant that 82.1% of the variance of the indicator was explained by the construct.

Table 5: Convergent Validity

	Average variance extracted (AVE)
FA	0.747
FI	0.694

FL	0.821
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4.2.4 Discriminant Validity

Discriminant validity ensures the empirical distinctiveness of each construct in relation to other constructs in the research framework. The current study considered discriminant validity using the HTMT ratio and Fornell-Larcker criterion, as suggested by Hair et al. (2022).

4.2.4.1 Heterotrait-Monotrait Ratio (HTMT)

The acceptable levels of discriminant validity using the HTMT test include values that are less than 0.85 (or 0.90). In this study, the HTMT values are way below the suggested threshold. The HTMT values between FA and FI are 0.119, FA and FL is 0.615, and FI and FL is 0.314. Since all HTMT values are considerably less than 0.85.

Table 6: HTMT

	FA	FI	FL
FA			
FI	0.119		
FL	0.615	0.314	

4.2.4.2 Fornell-Larcker Criterion

According to the Fornell-Larcker criterion, the square root of the AVE of each construct should be greater than its correlations with all the other constructs. The square root of AVE was found to be 0.864 for FA, 0.833 for FI, and 0.906 for FL. For example, the square root of the AVE of FA was greater than its correlation with FI (0.646) and FL (0.588). The other constructs, FI and FL, have also fulfilled the Fornell-Larcker criterion.

Table 7: Fornell Larcker Criterion

	FA	FI	FL
FA	0.864		
FI	0.646	0.833	
FL	0.588	0.235	0.7906

4.2.5 Coefficient of Determination (R^2)

The strength of explanation from the structural model was determined based on the coefficient of determination (R^2). As per Hair et al. (2022), coefficients of determination of 0.25, 0.50, and 0.75 indicate weak, moderate, and high explanatory powers, respectively. Based on the above findings, FA received an R^2 of 0.430 and an adjusted R^2 of 0.419. Hence, FI and FL are responsible for 43.0% of the variation in FA among SMEs. Although a considerable amount of the total

variation is not explained by the model, an R^2 of 0.430 indicates moderate explanatory power and indicates that the two independent variables are significant determinants of FA among SMEs.

Table 8: R-Square

	R-square	R-square adjusted
FA	0.430	0.419

4.2.6 Effect Size (f^2)

The Effect Size (f^2) is the unique contribution of the exogenous constructs towards the explanatory power of the endogenous construct, holding other predictors constant. According to Cohen (1988), 0.02, 0.15, and 0.35 represent the cutoff points for small, medium, and large effect sizes, respectively. In this study, FI presents an f^2 value of 0.150, which is indicative of a medium effect size on FA. In contrast, FL provides an f^2 value of 0.719, which is quite higher than the value of a large effect size. This implies that FL has more influence on FA than FI for SMEs. Psychometric properties of the MM are very reliable. All indicators have outer loadings well above the recommended threshold, suggesting high reliability of the indicators. CBA and CR values show that all constructs are consistent with excellent internal consistency, whereas AVE values suggest convergent validity. Moreover, the HTMT ratio as well as Fornell-Larcker criterion show that there is discriminant validity in the MM as each construct is conceptually and statistically distinct. Coefficient of determination and effect size show that FI and FL contribute significantly towards the predictive power of FA amongst SMEs.

Table 9: f-Square

	FA	FI	FL
FA			
FI	0.150		
FL	0.719		

4.3 Structural Equation Model (SEM)

4.3.1 Structural Model Assessment

After establishing the reliability and validity of the MM, it was the turn of the SEM to be evaluated, whereby the proposed relationships between the exogenous constructs and the endogenous construct were investigated.

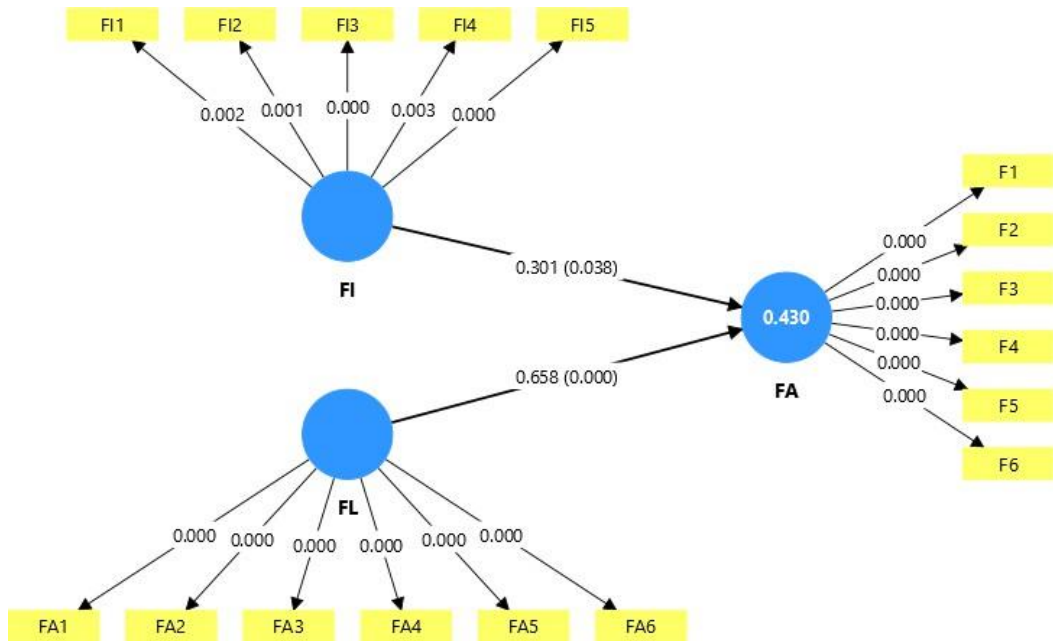


Figure 3: Structural Equation Model

4.3.1.1 Hypothesis Testing

The structural relationship was analyzed using path coefficients (β), t value, and p value obtained from bootstrapping technique. The findings of the path coefficient and hypothesis test are shown in Table 8, which includes the coefficients, standard deviation, mean, t value, and p value.

Table 10: Path coefficient

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
FI -> FA	0.301	0.269	0.145	2.073	0.038
FL -> FA	0.658	0.645	0.078	8.472	0.000

H1: Financial inclusion has a positive and significant effect on FinTech adoption among SMEs in Pakistan.

Empirical findings confirm that the path coefficient between FI and FA equals $\beta = 0.301$; its t-value and p-value are equal to 2.073 and 0.038, correspondingly. Since the t-value is higher than 1.96 and p-value lower than 0.05, the relation is significant statistically. The positive standardized coefficient ($\beta = 0.301$) proves that enhancement of FI positively contributes to the implementation of innovative FinTech solutions by SMEs. Therefore, it can be stated that SMEs have a high likelihood to use innovative FinTech technology if they have better access to formal

financial services, banking institutions, digital payment systems, easy excess to internet to use these services and financial infrastructure.

Higher participation in activities of FINs leads to familiarization with digital financial services, which contributes to the use of FinTech technologies in financial activities. The empirical findings support the assumptions of the TAM theory. According to TAM, FI is an external facilitating condition that positively influences the perception of usefulness and accessibility of FinTech technologies. Moreover, access to financial resources can be considered as one of the organizational capabilities that allow SMEs to invest in digital technologies and develop competitive advantages. Therefore, Hypothesis 1 is supported, confirming that FI is a positive significant predictor of FA among SMEs in Karachi. It means that easy excess to users of financial services helps the customers to use the services on frequently basis, which ultimately boost the FI in Pakistan.

H2: Financial literacy has a positive and significant effect on FinTech adoption among SMEs in Pakistan.

The bootstrapping analysis reveals that the standardized path coefficient between FL and FA is $\beta = 0.658$, with t-value = 8.472 and p-value < 0.001. Given that t-value greatly surpasses the critical value of 1.96 and p-value is much smaller than the significance level of 0.05, the above relationship is very significant. This shows that FL has an excellent impact on FA of SMEs. The standardized coefficient ($\beta = 0.658$) proves that FL is the best predictor of FA in the proposed research model. Owners of SMEs with higher financial knowledge, financial planning capabilities, budgeting skills, investment knowledge, and knowledge of digital financial services are more likely to adopt FinTech technologies in their businesses. Financial literate managers are more confident in assessing digital financial products, technologies, financial risks, and adoption of digital financial services. These results are consistent with the theoretical basis of the study, providing strong empirical support for the TAM. According to TAM, FL affects positively users' perceptions about the usefulness and ease of use of FinTech apps, thus promoting technology acceptance. In addition, the knowledge of financial matters by managers is seen as an important intangible resource of organizations that can improve their innovation and technological competitiveness. Therefore, Hypothesis 2 is accepted, confirming that FL significantly promotes FA among SMEs in Karachi, Pakistan.

4.4 Discussion of Structural Model Results

As for the outcomes from the SEM, it can be stated that both FI and FL play a significant role in shaping the level of FA for SMEs. However, the strength of the impact of FI and FL on FA differs greatly. First of all, FI shows its weak positive influence on FA ($\beta = 0.301$, $p = 0.038$). It can be explained by the fact that financial access along with FINs and services contributes to FA of the firms; however, financial access cannot guarantee high FA levels. On the other hand, the impact of FL on FA is much stronger and positive ($\beta = 0.658$, $p < 0.001$). The above findings clearly indicate that, despite availability of financial services, SME managers need

to have adequate knowledge regarding finances so that they can appreciate the advantages offered by FinTech and utilize the technology in their businesses. Additionally, the SEM generated an R^2 value of 0.430, meaning that FI and FL combined account for about 43.0% of variation in FA behavior amongst SMEs. As per Hair et al. (2022), this shows moderate predictive power in the model. Nevertheless, about 57% of the variance is still unexplained, indicating that other factors/variables might be playing an influential role in affecting the financial adoption among the SME owners and should be investigated in the subsequent research studies. The effect size (f^2) analysis also strengthens the above conclusion. FI shows a medium effect size ($f^2 = 0.150$), whereas FL shows a large effect size ($f^2 = 0.719$). This again verifies the fact that FL plays a significantly larger role in accounting for the variance in the financial adoption than FI. Thus, from the above findings, we can conclude that improving the financial capacity of SME owners helps in bringing about the desired digital financial transformation than trying to focus only on increasing the financial services access.

5. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This study aimed to analyze the impact of FI and FL on adoption of FinTech services among SMEs in Karachi, Pakistan. Based on the principles of the TAM, it was assumed that better access to FINs and FL would have a positive effect on the use of financial technologies by the SMEs. In the course of primary data collection, the respondents included the SME owners / decision-makers in Karachi, who were surveyed via a structured questionnaire. The data analysis was performed using PLS-SEM with SmartPLS 4 software. The evaluation of the MM proved that all constructs met the required standards for reliability and validity. Indicator reliability was proven since all the factor loadings were greater than 0.70. The internal consistency was supported by CR and CBA values, while the AVE proved satisfactory convergent validity. Discriminant validity was also validated via HTMT ratio and Fornell-Larcker criterion values, which proved that all constructs were empirically distinguishable. The findings proved that the measurement tool had proper psychometric characteristics for testing the structural model.

The SEM findings suggest that the FI had a positive and statistically significant impact on FA, meaning that SMEs with better access to formal FINs and digital financial platforms are more prone to adopt financial technologies. However, the effect size of FI is moderate, which means that financial accessibility is not sufficient to predict technology adoption. On the other hand, FL also had a positive and statistically significant impact on FA and is regarded as the best predictor in the research model. This means that owners and managers of SMEs who have a good financial knowledge are more likely to adopt financial technologies.

The model explains about 43% of the variance of FA, which means that its explanatory power is moderate and that there are other factors that could affect technology adoption decision of SMEs. The results support theoretical assumptions of the Technology Acceptance Model, according to which the impact of external

organizational factors is important for technology adoption behavior. The access to formal FINs and digital financial infrastructure provides SMEs with more information about the use of FinTech services.

FL helps managers become better aware of the importance of finances and decreases uncertainty regarding technologies. FI and FL can be considered as important resources within organizations that help in increasing the capability of SMEs to adapt to the use of digital financial technologies, thus making the firms competitive. This paper adds to the knowledge base of digital finance through the use of TAM among SMEs in an emerging economy. Unlike previous papers which have mainly focused on individual consumers or users of mobile banking, this study has focused on organizational technology adoption among SMEs in Pakistan, which is a notable contribution to the existing body of knowledge.

5.2 Practical Implications

The findings from this study have a number of practical implications for policymakers, FINs, FinTech firms, SME owners, and business support organizations. Policymakers including SBP, SECP, and SMEDA need to encourage the expansion of FI interventions which aim to improve the access to financial services by the SMEs. Policies aimed at promoting digital banking, branchless banking, digital payments solutions, and SMEs financing solutions hasten the process of FA and digital economic development.

Banks, as well as other FINs, should design financial solutions which are digital and SME specific and easy-to-understand and affordable for small businesses. Cooperation between banks and FinTech firms is important for designing an ecosystem of digital financial solutions that facilitate digital payments, digital lending, online invoicing, and cash flow management. This study highlights the importance of FL for facilitating the process of FA. University bodies, business associations, chamber of commerce, and government bodies need to arrange FL and digital financial solutions capability workshops for SMEs owners. The topics covered under such workshops include budgeting, financial planning, investment appraisal, digital payments, and awareness of cyber threats, financial risk management, and FinTech applications.

FinTech organizations must endeavor to create easy-to-use technologies that minimize the technological complexities and provide full customer support and training. Simple and easy digital interfaces, multilingual software, and continuous customer education contributes to easier adoption of FinTech services by SMEs of varying degrees of FL. The managers of SMEs should see the FL as an organizational capability as opposed to an individual one. Investing in the FL of managers improve their ability to adopt new financial technologies.

5.3 Recommendations

It is recommended that the Government of Pakistan improve its policies to boost FI among SMEs through increasing digital financial infrastructure and encouraging

the formal participation of SMEs in the financial sector. FINs should endeavor to make loan application processes simple, streamline paperwork requirements and design digital financing solutions suited to the needs of SMEs. The SBP should continue efforts to encourage cashless transactions and the creation of digital payment systems through widespread adoption of mobile banking, QR code payments and digital wallets by SMEs. This helps to cut down on transaction costs and improve business efficiency. The SMEDA and other business development organizations should put in place continuous capacity building programs that focus on FL and digital financial management. Financial education should be incorporated as an essential element of SME development programs in all regions. Universities and business schools should partner with FINs and FinTech firms to organize executive training programs on digital finance and financial planning. Also, SMEs should initiate their own digital transformation process through employee training, digital payment solutions and improved financial skills among managers.

5.4 Limitations of the Study

Although this study contributes useful information about determinants of FA of SMEs, there are some limitations to consider. The first one is associated with geographic limitation because it was confined to SMEs located in Karachi only. It does not make results of the study applicable to SMEs in other parts of Pakistan. The second limitation refers to the research design because the cross-sectional research was used to collect data from respondents. This made it impossible to examine any causation or temporal effects related to FA behavior of the respondents. Using longitudinal designs can help understand better the dynamics of digital technology adoption by SMEs. The third limitation is associated with using only two independent variables in the analysis, FI and FL. Even though the developed model explained a large portion of variance in FA, adding more determinants such as digital literacy, readiness for the use of digital technologies, organizational culture, innovation capability, cyber-security issues, government policies, trust, perceived risk, and top management support could improve the model significantly. The fourth limitation is associated with self-reported questionnaire because it may cause the problem of common method and social desirability biases despite the use of appropriate measurement scales and statistical control.

5.5 Directions for Future Research

There is scope for extending this study along several dimensions. For instance, research that focuses on different SMEs located in other provinces in Pakistan it will increase the generalizability of the findings. Research that includes a number of developing nations may provide deeper understanding about contextual differences associated with FA. Longitudinal research designs may be used to explore the relationship between FI, FL and FA over time. Some of the factors that may be considered include: digital literacy, innovation capability, organizational readiness, perceived risk, cybersecurity awareness, government support, institutional quality, and trust. Future research may also focus on the mediating or

moderating variables like organizational innovation, digital capability, entrepreneurial orientation, or technological readiness in order to shed light on how FI and FL impact technology adoption. Multi-group analysis where SMEs in manufacturing, services, retail, and technology-based industries are compared will yield insightful results. This study reveals that both FI and FL have a significant positive effect on FA in SMEs in Karachi, Pakistan, and FL emerges as the more influential determinant. It is clear that any effort to facilitate access to formal FINS should be coupled with initiatives that aim at increasing the financial capabilities of entrepreneurs.

Declaration of Interest Statement

The authors have no conflicts of interest.

Data of Study

All the ethical considerations were followed in data collection. Data can be availed upon request.

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